International Journal of Engineering & Technology, 7 (3.10) (2018) 207-210

International Journal of Engineering & Technology

Website: www.sciencepubco.com/index.php/IJET

Research paper

Experimental and Analytical Study of Different Fiber Reinforced Composites with Damage

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Abstract

Composites are the materials which are majorly used in applications of aerospace, defense, transportation, communication, power, electronics, recreations porting and other commercial and consumer products. It is thus becoming more and more important that long term behavioral characteristics of the materials and structures are understood and implications of variety of flaws determined with respect to load conditions. This is to pay particular attention to fiber reinforced composites and its damage. The composites have fibers. Interwoven in orthogonal directions and cracks were introduced in different angles and composites coupons were undergone experimental procedures so that variation of tensile strength and stress strain curves are possible to study their effect on the composites. Different characteristics of damage on failure and remaining life were been clearly viewed by the result of non- linear finite element models tensile test were carried out using standard conditions

Keywords: *Composites, Experimental Tests, Damage, Repair, Crack*

1. Introduction

The combination of matrix and reinforced substance forms super strong materials usually called composites materials. Composites have various qualities likes higher in strength weight ratio. Flexibility, super resist vibration, fatigue resistance and also tensile strength.

Depends upon the demands of the materials with varying application to the different fields, the composites materials are newly developed and fabricated. Mostly the research area concentrate on the behavior, transition cracking stage of damage based upon the applications.[3] proves that weakest link fails on testing.[5] states that due to micro cracks occurs in polymer composites has ability to alter the alignment with the effort direction. In this study, tensile properties of bidirectional carbon composites are discussed. Characterization of carbon matrix composites (CMC) with damage and glass matrix composite (GMC) with damage and different types of micro level cracks are studied deeply. Damaged coupons are compared for their strength.

Finite element method is numerical method that is carried out in an attempt to earn numerical values.

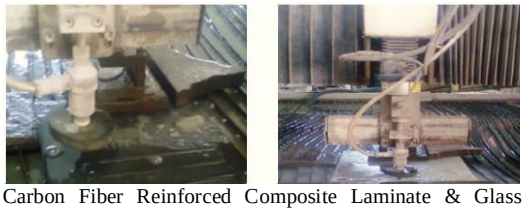

Fig.1: Carbon Fiber Reinforced Composite Laminate & Glass Fiber Reinforced Composite Laminate Cutting Process.

2. Experimental Methodology

2.1. Material and Preparation of Coupons

[6] This investigation conducted on bi-directional carbon fiber and glass fiber composites its can be fabricated using vacuum bag techniques and its curing process of not less than 24 hours with post curing at 100^0c for not less than 2 hours. The size and shape are all depends on ASTM standards. And all specification based on [6]. High strength Araldite epoxy adhesive were used to bond the Aluminum tabs on both sides.

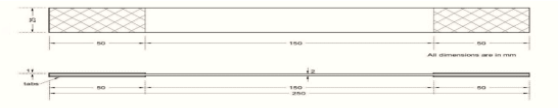

Fig.2: Sketch of Coupon (ASTM D3039)

Fig.3: Untested Coupons of CFRP and GFRP (Without Damage)

2.2. Generation of Crack

After coupon is cut according to above mentioned dimension crack has made on it. Crack is generated with a blade of 0.5 mm thickness with lathe machine. Damage (crack) has a dimension of 10mm length , 0.5 mm thickness and 1mm of depth. Fig.4 shows the crack or damage formation on coupon with the help of lathe machine, Fig.5 shows some of the coupons with damage.

Fig.4: Making Damage on Test Coupon with Lathe Machine

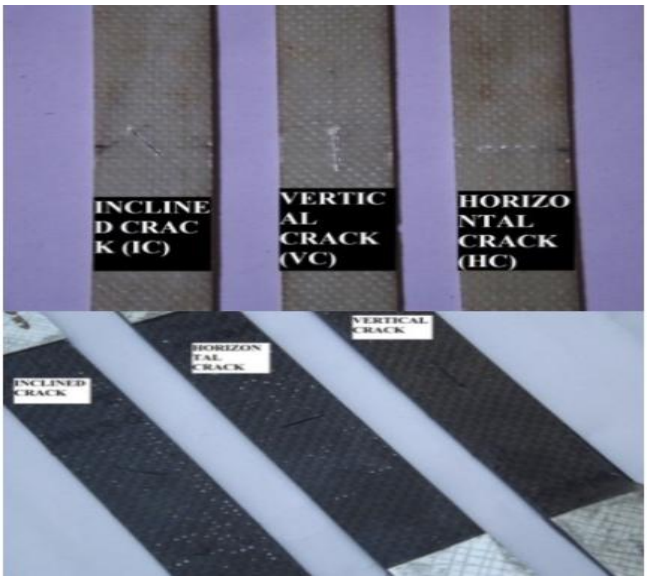

Fig.5: Untested Coupons of CFRP and GFRP (With Damage)

2.3. Testing Machine

The tensile test is being resulted from the universal testing machine (UTM) machine with maximum capacity of 400KN. FIE make UTM 40 model UTM machine is used here.
For all the coupons the crosshead travel was maintained at 0.15 mm/min. The tests which are done by UTM are preformed at ambient temperature and the grips were fixed in such neither bending nor testing undamaged and damaged specimens.

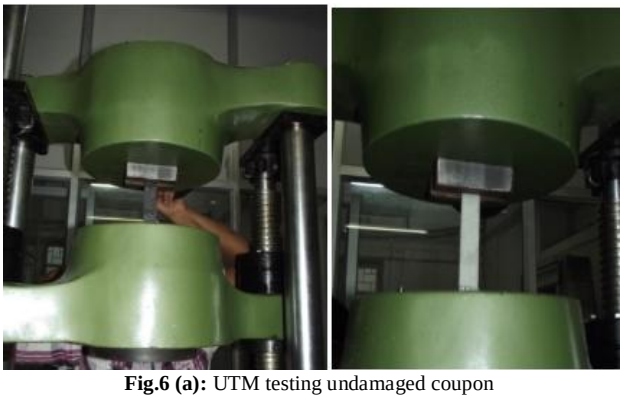

Fig.6 (a): UTM testing undamaged coupon

Fig. 6(b): UTM testing damaged coupon

3. Analytical Studies

Analytical modeling for response assessment
To estimate displacement and stresses, static analysis method is used. Both linear and non-linear static analyses are done by static loading conditions. Plasticity, stiffening, large strain, hyper elasticity and creeps can be included in non-linearities.
From the analysis done by the ANSYS 12 the details of analytical study and linear analysis accounting material changes are analyzed for the idea of location and propagation of cracks. For that purpose the element plane 82 is the best suited to this problem.
To analyses the various damages on specimens are modelled by using the minimum values of experimental results.
By assuming are formed on boundary regions that are shown in figures.
Various analysis were carried out with following damage and parameters. Considering the damaged and undamaged loads with parallel inline and normal to the loads.

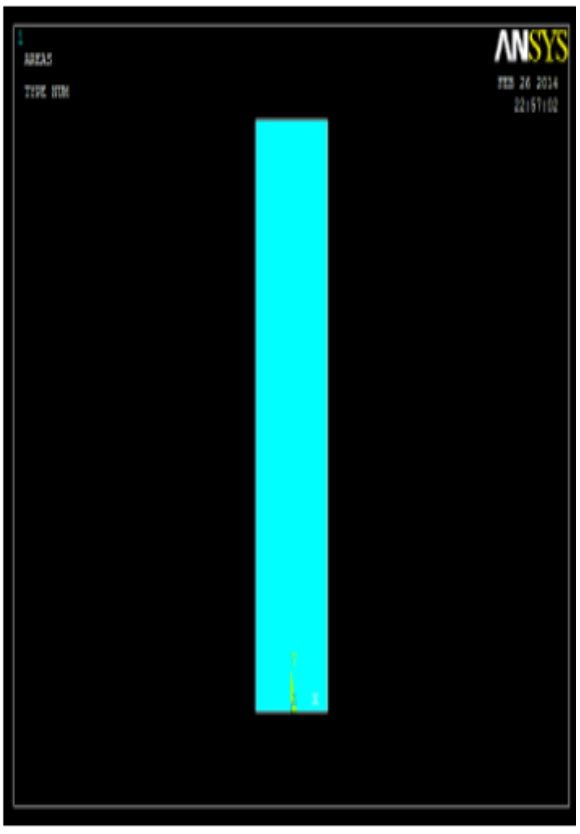

Fig.7 (a): Specimen Region

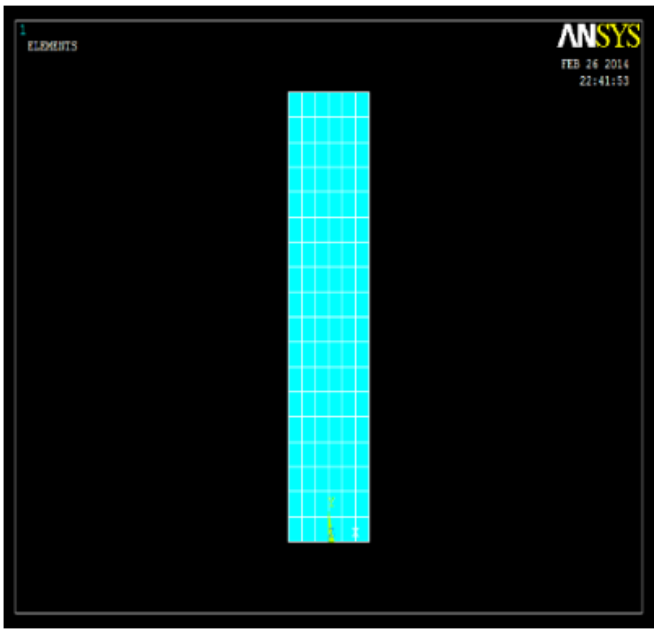

Fig. 7(b): FE model

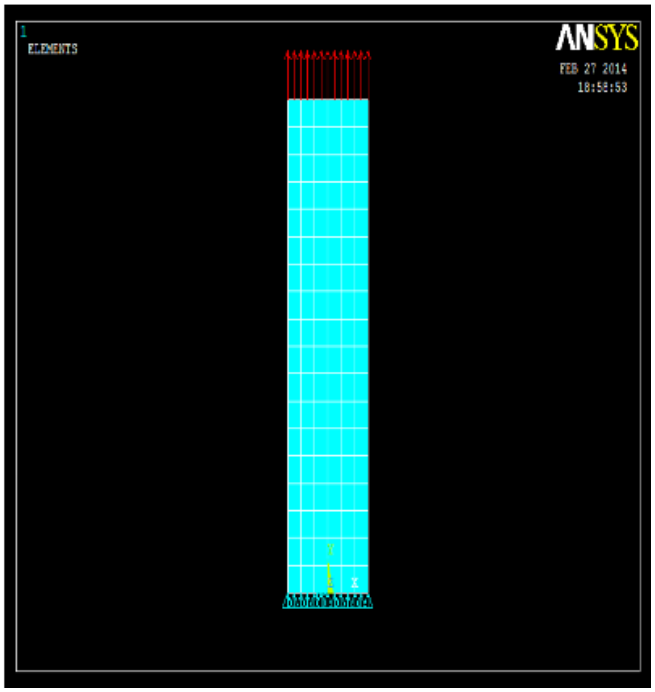

Fig.7(c): Loads and Displacements

4. Results and Discussions

The result have been presented in two groups, i.e. the result for the virgin coupons, the results for the induced crack with different orientation in the coupons. The tensile strength values obtained with induced cracks in the coupons with tensile test in UTM compared with virgin coupon's tensile strength. Fig 8 shows stress vs strain variation with differently oriented damaged coupons and repaired coupons.

(a) Shows the stress vs strain curve variation on generations of cracks in different orientations on the virgin coupons of CFRP material.

(b) Shows the stress vs strain curve variation on generations of cracks in different orientations on the virgin coupons of GFRP material.

The result are verified by the FEM analysis. The nodal displacement solution of virgin (CFRP) specimen is shown in fig.8.

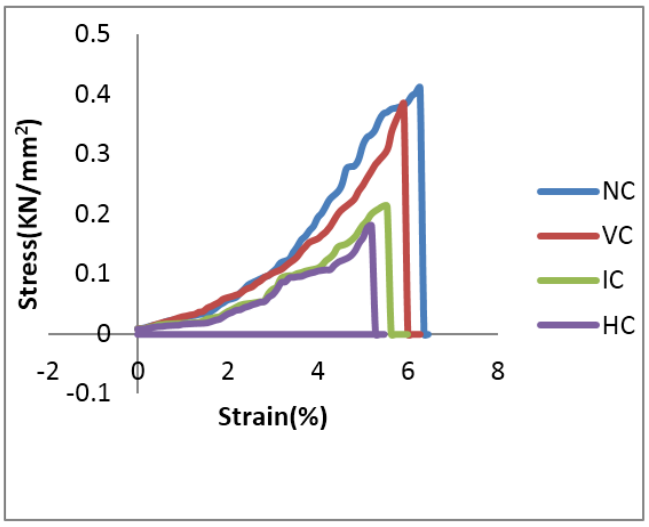

Fig.8 (a): Stress Vs Stain Curve for Coupons with No Crack, Vertical Crack, Inclined Crack and Horizontal Crack

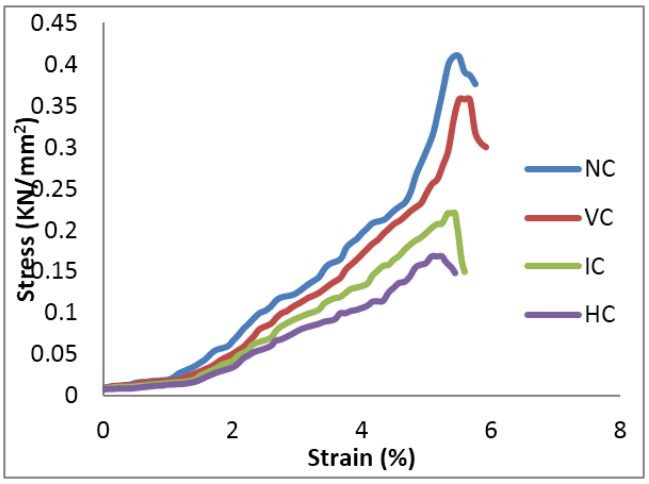

Fig.8 (b): Stress Vs Strain Curve for GFRC Coupons with No Crack, Vertical Crack, Inclined Crack and Horizontal Crack

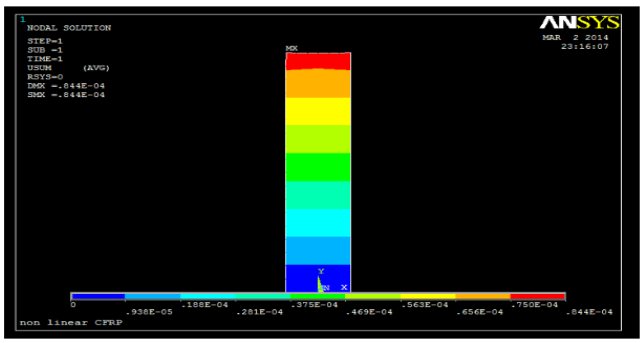

Fig.9: Shows the Nodal Displacement of CFRP Specimen with No Crack

5. Conclusions

As a result conduct by UTM under environmental conditions out of all induced cracks in the coupons horizontal induced cracks are the dominating factor. Whereas the strength is highest in the virgin coupons. Catastrophic failure in the aerospace vehicles can be occurs due to the horizontal induced cracks because of perpendicular in direction to the fiber loading. Hence we can conclude that the tensile strength of damaged carbon fiber bi-directional composite specimens will be less if the crack is perpendicular to the loading direction and tensile. The result are also verified by the linear static analysis of both CFRP and GFRP coupons.

Acknowledgement

The authors gratefully acknowledge the support of C.Dhavamani and Mr. Mohammed kazzali for their excellent guidance.

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